AN INVESTIGATION INTO CURRENT CONSTRUCTION ENGINEERING AND MANAGEMENT PROGRAMS AND CURRICULA AND THEIR APPLICABILITY TO THE U.S. ARMED FORCES

A Special Research Problem

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INTRODUCTION

The purpose of this paper is to research and explore the available programs and curricula in Construction Engineering and Management and assess their applicability to the needs of the civil engineering segments of the U.S. Armed Forces. The writer's interest in this subject was piqued by discussions with fellow officers who had attended various institutions for similar programs. Opinions and levels of satisfaction with the programs seemed to vary widely, yet no apparent action had been taken to guide potential students to the more gratifying and appropriate schools.

To identify the need for construction engineering and management, a short history of construction education is presented. Turning next to industry's desires, an examination of what the construction industry is looking for from construction education is made. Looking then from the other side of the fence, an explanation of what the industry can provide the educational establishment to further promote the field is given.

In order to better understand what the military civil engineer needs in an education, a synopsis of duties and functions of each service (Army, Navy, and Air Force) is provided. A comparison of the tasks performed and educational programs available is presented.

Realizing that a variety of forms of contracting methods exist, the writer chose to look closely into that of Construction Management, believing it to be the most like the military member's role. The Construction Management delivery system is defined in depth, and similarities and differences are noted between this system and the needs of the military engineering programs.

To get a feel for the long range use of this educational program, a survey of senior officers was made. Their impressions of this curriculum over other available engineering programs and discussion as to what they would look for in a program today are presented. Their views on the direct use of this graduate education as well as indirect benefits of the graduate school program in general are discussed.

For the purpose of evaluating and comparing institutions and their particular Construction Engineering and Management programs, a applicability evaluation system is developed and discussed. The system is then applied to twenty schools with current construction education programs and the results are presented.

An overview of the author's findings and interpretations of those findings conclude this project.

HISTORY OF CONSTRUCTION ENGINEERING PROGRAMS

The development of the construction engineer and manager through formal educational channels did not begin until the 1920's. Prior to this time, the manager, typically the general contractor, was an individual who had worked his way up from apprentice to master. Striking out on his own business venture, all talents he had not developed as an employee were left to be acquired through the school of hard knocks. The capable and cunning surviving to prosper while the others floundered and failed (as they still do today with construction contractors reporting the country's highest business failure rate)[Dunn87].

As building construction became a more exacting profession, builders became painfully aware of the shortcomings both civil engineering and architecture programs had with respect to their actual job demands. Knowledge needed by the construction engineer was a combination of topics found in each curriculum along with some subjects not included in either.

The best estimate as to when formal educational programs and courses began to service the needs of the building constructor appears to be in the mid 1920's. A number of fairly similar programs catering to the needs of the construction industry were initiated at various institutions in that period with no one group (as far as the writer could find) claiming to be the first.

In their infancy the programs met head on with the Great Depression, which took its toll on university enrollment and forced many program mergers. So back into the folds of the well-established and more traditional areas of civil engineering and architecture went these fledgling curricula to linger until the more prosperous times could revive them.

The need for and role of construction engineering education persisted even through the rough times of the 1930's. Professional organizations gave much credence to the fledgling profession by appointing committees to investigate and study construction engineering. The American Society of Civil Engineers in 1933 formed a committee on Construction Engineering Education. Following a year later was the Committee on Construction Engineering appointed by the Civil Engineering Division of the Society for Promoting Engineering Education (later renamed the American Society for Engineering Education). The two committees joined forces to survey schools to find out what courses were currently available in the construction area. The survey indicated that only a precious few of the 140 schools queried offered a special construction curriculum or a construction option within their Civil Engineering Program. The vast majority of institutions offered elective/required courses in construction or had incorporated construction topics into the standard civil engineering material. The most commonly found courses were those dealing with: a) legal principles covering

contracts, specifications, compensation and liability insurance, b) cost estimating and cost keeping, c) construction equipment, plant layout and job management[Huntington36].

The joint committee had high expectations of discovering what was best taught in the classroom as opposed to what should be left to be learned on the job. Surveys of texts and research materials were planned along with requests for the development of new material desired to properly teach classes in construction engineering. But these good intentions of the committee remained only that. The depression and World War II had severely stunted the growth of construction engineering and management as a recognized curriculum and profession.

Though restrained, construction engineering never totally faded from the academic realm through the 1936-1946 period. To add to the problem of the economy being against it, the program also had its critics and doubters that saw all of its subjects as training to be acquired on the job. Universities relished the idea of producing professionals (classical engineers and architects) and shied from the idea of training technicians. Contractors and Construction Engineers may also have been reluctant to share some of their hard-earned knowledge or tricks of the trade with students still in school, rather allowing them to pick up the skills in the school of hard knocks instead of a college classroom. Just how serious was this need for

construction education anyway? Was it enough to justify the development of a separate program or highly-modified curriculum?

An Engineers Joint Council survey in 1946 attempted to determine the fields of industry in which civil engineers were employed. Of 8,700 civil engineers polled, 63.9% named construction as their major area of operation, far outdistancing the second named field of utilities with its 8.9% share. Further supporting data showed the Construction Division of the American Society of Civil Engineers to be the largest with 25% of the society's membership[Nikirk49]. Construction costs in that year (1946) were 10% of the national income and totaled $15,000,000,000[Babcock48]. Armed with these statistics, a case could be made for the need of a curriculum in Construction Engineering. But what exactly constitutes a construction engineering curriculum and how is it to be taught?

Inconsistent expectations of the curriculum led to opinions on the program's content being as numerous as the programs themselves. The single, most major difference seems to be the degree of specialization desired. Those in favor of specialization embraced the idea of creating experts in a particular area. Those opposed claimed students would become dependent on handbooks and formulas thus failing to learn the general principles of engineering[Haertlein37].

As stated earlier, the majority of institutions adapted an existing curriculum to fit the variety of needs of the construction engineer. However, not everyone believed construction engineering to be a sub-category of civil engineering. Some saw the civil engineer as the designer, oriented toward ideas, while the construction engineer was the individual getting the job done and concerned more with the human relations aspect of the job[Nettleton44 & kellogg51]. They thought that the construction program would evolve and become a separate curriculum and take on its own singular identity.

Yet too much differentiation from an established engineering program posed the consequence of individuals not being able to meet the requirements for professional registration. Furthering the belief that "the basic principles of engineering were the most important" was the fact that many other engineers of disciplines other than civil were doing competent work in the construction arena. From this realization of the importance of a "basic engineering principles" background, came the widely accepted curriculum employed by most institutions[Oglesby48].

Proponents of both the group advocating a mega-dose of construction training, as well as the backers of the strict civil engineering curriculum, came up with strikingly similar proposals. Each side called for the initial three years of education to follow the traditional curriculum that is required

of all civil engineering students. The last year would be reserved for specializing in the construction "option" courses.

The two main categories that the construction courses fell into were: a) direct construction subjects; and b) affiliated support subjects. Included in the direct topics are construction management, methods, plant, and cost estimating. Subjects representative of the support category are accounting, economics, and engineering law. Many arguments existed for the various construction courses but one was particularly poignant. A contractor, G. MacDonald, in the support of cost estimating stated "no matter how much of a philanthropist one believes himself to be, it is not much fun to work for nothing, and still less fun to have to pay for the privilege"[MacDonald41]. (A side note to the construction spin-off was the adoption of a "costs" course by the design option to give those not in the field a better feel for hourly equipment rates i.e. they could look at a backhoe in the parking lot and see $35.00/hour vice only a digging machine)[Oglesby48].

With the end of World War II, the last major economic obstacle was removed from the path of construction engineering. College campuses were again full and programs began to expand to cover fields of possible professional employment. Even in light of this, only six institutions were offering a construction engineering option to civil engineers in 1946[Ledbetter85].

Professional societies and private organizations began to lobby for expanding existing programs and introducing new ones at schools that currently had none. Though virtually never heard from before in the academic world, state chapters of the Associated General Contractors became supporters of new educational courses that would benefit the construction industry. The American Society for Engineering Education (formerly the Society for Promoting Engineering Education) reorganized their once ambitious Construction Education Committee. Once fully staffed, the committee began the process of establishing new construction options at more universities along with enriching and expanding the offerings within existing programs. To introduce new, never-before, classroom-taught subjects new textbooks were needed. In many instances, the committee members themselves were ultimately the source of these monographs [Ledbetter85].

As subject offerings expanded, the need for additional classes to complete a well-rounded educational program was brought to light. A few schools made the bold step to change from a four year B.S. program to a five year program and offer an M.S. degree. Their reasoning was that in order to maintain the "basic principles engineer" and add to that management topics such as labor relations, methods improvements, organizations, engineering economy, and planing & scheduling, an additional year was required (and still insufficient in many eyes). Most

programs have however, fought off the temptation to expand to five years and retained the common, four year program. In currently available, accredited, engineering undergraduate programs, the curriculum varies little between schools. With a predominance of four year B.S. degree schools (vice five year M.S. programs), the need for graduate programs has flourished.

And flourish the graduate programs have, gaining more popularity and being offered at ever increasing numbers of institutions. The top civil engineering departments have strong graduate programs in the area and several award more graduate degrees in construction engineering and management than in any other civil engineering specialty[Carr83]. The graduate curricula exhibit considerably more variation between institutions than does its undergraduate counterpart. Within each graduate program is normally found a great deal of latitude to allow the individual student to pursue his or her interests. The most common course of study is based around a set of required core courses, normally making up between one third to one half of the total number of credits or units needed to obtain the degree (yes there are exceptions on either end of the scale with one program not requiring any civil engineering or construction courses except the thesis). Nearly every school encourages the student to expand their horizons and take relevant courses from the other colleges or departments within the institution. Many have required courses from other areas to ensure this exposure.

To sum up the topic of construction engineering education on the graduate level the best, single word would be **dynamic.** The programs are still wet behind the ears in comparison with classical engineering. Nearly every day, new and different directions are being realized (I use the word realized instead of discovered because many of these areas have been around for a long while but we are only now beginning to recognize their possibilities and worth). Construction engineers and managers have a vast array of areas in which to specialize or work, as well as a host of potential employers willing to pay for their expertise. This is truly an expanding and maturing profession.

WHAT INDUSTRY WANTS FROM CONSTRUCTION EDUCATION

The question of what the construction industry wants from college level educational programs has been asked many times with varying rates of success in obtaining meaningful answers. Philosophically speaking, the industry has always wanted capable, dedicated, ethical, and highly-motivated people to manage the planning and implementation of construction projects[Oglesby82]. But how does that translate into what institutions need to be teaching in order to provide such individuals? In 1949, Robert L. Peurifoy compiled the results of a questionnaire he had sent to Texas contractors to help determine what courses were needed by individuals coming into the construction field. Though he termed the response to his survey "gratifying", the opinions received varied so widely that no specific conclusions could be drawn from the data in most cases[Ledbetter85].

A few more recent surveys have met with discouragingly low response rates. In three separate questionnaires sent in June 1978, January 1982, and June 1984, C. Popescu obtained responses from 16.3%, 22.7%, and 17.8% respectively, of those polled. Each mailing consisted of over 350 firms listed as top U.S. contractors by the ENR directory of the appropriate year. Popescu's intention of serving the needs of the construction industry by promoting and maintaining an ongoing dialogue between professors and practitioners should be applauded and

supported from both groups. Unfortunately, this does not appear to be the case. As is obvious from the response rate, industry is not overly concerned about the content of graduate education (or they're just too busy making money).

The blame does not lie entirely with industry for this blocked corridor of communication. The Associated Contractors of America(AGC) has been actively promoting construction education curriculum development and has even offered financial assistance for the development. Sadly, these offers have fallen on deaf ears (in many cases) at major institutions and commonly find their way to building construction technology programs that readily embrace them[Jones88]. The information that was discernible from the three surveys of Popescu was a trend in the shift of priorities. The major shift noted was to the topic of legal issues in construction and project management. The category was not in the top ten of the 1978 poll but topped the list in the two subsequent questionnaires.

Another noteworthy trend seen in the 1984 survey, that is also supported by a separate poll conducted by D. Oberlander, was the desired emphasis on communications skills. From the data presented, it was unclear as to whether the employers were dissatisfied with employees current abilities or if it was simply viewed as a skill at which it always pays to be more efficient. Popescu's work also indicated, without a doubt, that a masters

degree was not a requirement for promotion in the construction industry. Another point brought out was the perception that an individual with an advanced degree and no practical experience is over-educated for the employer's purposes[Popescu87].

At approximately the same time as the last of the Popescu polls was being conducted, a totally separate survey was being accomplished by the school of Engineering at the Oklahoma State University. This survey, claiming to be the first to ask for input from contractors on desired graduate course work, queried contractors with one questionnaire to determine their perception of the relative importance of an extensive list of topics. It also requested they determine appropriate levels of effort of research to be devoted to specific areas named.

A second, comparable form was sent to institutions with graduate Construction Engineering and Management programs, requesting they list the current levels of effort in both instruction and research. All topics and areas of research covered by the contractor poll were named in the school's questionnaire. The results were surprisingly similar and the percentage of respondents commendable in comparison with the earlier polls mentioned. An impressive 74% of the 34 schools returned completed questionnaire as did 49% of the 222 small to large sized general and specialty contracting companies.

The widest divergences between educator and practitioner came in the areas of planning and scheduling, project controls, supervision, and particularly in specialty courses. In planning and scheduling, approximately 20% of the contractors indicated no need to study PERT or "other" techniques in progress charting (bar charts and CPM were both almost unanimously desired). Under project controls, universities stressed operations research much more than companies, but failed to cover cost and quality control and safety as extensively as was desired by the firms. In the supervision arena, the desires of contractors, as stated earlier, was to better develop the communications skills of the graduates. Across the board in communications, the sub-categories of verbal, written, and reports, companies desired a higher level of training than that currently provided by institutions.

The final topic of specialty courses included sales, electrical, mechanical, industrial processes and others. From the data it was clear that contractors perceived a much greater need for study in these areas than is now available. When it came to the desired level of research, nearly every sub-category under the specialty heading indicated that private construction companies and educational institutions were totally out of sync [Oberlender87].

Despite the exceptions just discussed, there appears to be a very favorable match up between institution offerings and

contractor requirements. If we discount the specialty area due to its restrictive, specific nature, there is an approximate 95% correlation between available courses and perceived needs.

WHAT CONSTRUCTION EDUCATION NEEDS FROM THE CONSTRUCTION INDUSTRY

The objectives of a Construction Engineering and Management program are many fold. Obviously, the most important task is that of educating professionals to fill responsible positions in all areas of construction. Other ambitions include enlightening students to the complex social, economic, political, and technological aspects of the field. Graduate programs must also attempt to be the leading edge in technological research and exploration to find solutions to the industry's growing maze of problems[Dietz76]. Definition of research needs, cooperation in research programs, and research **funding** are three related areas that can use as much assistance from industry as industry is capable and willing to provide.

Funding of research in the construction field has historically been dismally low, with what has been provided probably coming from government sources[Oglesby82]. An American Society for Engineering Education Construction Engineering Committee survey in 1980 reported that of thirty schools polled, only three had succeeded in obtaining sponsored research exceeding $100,000 in a two-year period. The study also indicated that seventeen of the institutions had no sponsored research what-so-ever[Newsletter80]. Why is it that construction programs have been expanding and gaining in popularity yet research funding has been almost non-existent?

The Business Roundtable report on Technological Progress in the Construction Industry suggests that the problem is key missing elements such as poor links between "needs and researchers" as well as between "researchers and users" [Business82]. Another fundamental problem with the Construction Engineering and Management field is its relative youth and therefore somewhat immature outlook on the subject of research. Those employed in the actual construction field, that is the successful ones, are often noted as the movers and shakers that go out and get the job done. As such, this writer believes, these individuals are not attuned to spending time or hard earned dollars on anything but that which can produce results in an acceptable time frame (by the end of the year, better yet by the end of the week)! Knowing this attitude exists many of the researchers in the construction field feel apologetic about research that "merely" advances knowledge[Carr83]. These are views that must change if construction research is to expand and become the vital part of the industry it has the potential for being.

Aside from research, funding is also required to expand and improve construction education. Some of the needs that might be satisfied were identified by an Associated General Contractors of America survey in 1981[ENR81]. Paraphrased they include:

1. Augmenting and retaining faculty. Included in this might be improving salaries, implementing endowed chairs, initiating summer work, consulting, and providing funds for travel and professional activities.

2. Improving physical facilities.

3. Providing scholarships and fellowships to attract good students.

There is a wide range of support that can also be provided other than monetary. Industry can enhance programs in a variety of ways such as providing advisory groups, speakers, and specialists to teach advanced courses, and arrange field trips.

"Looked at differently, what universities need from the construction industry is recognition that schools can and should do more than turn out graduates for the industry to hire. In particular, they should be encouraged to undertake research that can help to solve the industry's problems and to assist in providing the in-service education which the industry needs. To date, activities such as these have barely begun"[Oglesby82].

FUNCTIONS OF THE CIVIL ENGINEER IN THE ARMED FORCES

This chapter presents a look at the various tasks and duties performed by the officers in the civil engineering groups of the three armed services, Army, Navy, and Air Force. Concluding this chapter will be a brief assessment of the applicability of a Construction Engineering and Management program to the needs of these civil engineering groups.

U.S. ARMY CORPS OF ENGINEERS

Since June 16, 1775, the U.S. Army Corps of Engineers has been performing a multitude of missions for both the Army and the Nation. Since its inception, the roles of the organization have changed with the needs of the country, today encompassing a wide spectrum of responsibilities.

The direction for the Corps comes from the Chief of Engineers who is responsible for both the civil works and military missions of the Corps. Major categories of officer related responsibilities with the Corps of Engineers fall into several areas. First examined are those duties related to the active duty military troop units.

A wide variety of units are in the active army, and most fall into one of the following categories: (1) Combat Engineers, (2) Corps Combat Engineers, (3) Topographical, and (4) Combat Heavy. The Combat Engineer and Corps Combat Engineer units are similar, performing missions of engineer support to the battlefield commanders in their sector of resporsibility. Typical missions include the demolition of obstacles, installation of minefields and tank ditches, very light repair of roads and bridges, and installation of expedient bridging with special bridge units. These two types of units are typically assigned to a major army organization such as an Armored Division or to a Corp sized army unit.

Topographical units make up a very small percentage of the active army engineer force but perform important missions of map production and correction for field use. Combat Heavy units perform any level of construction, as this is the unit that has large quantities of earthmoving equipment, as well as tradesmen in the fields of carpentry, electrical, masonry, surveying and so on. Typical jobs performed by these units include airfield damage repair, assault airstrip construction, fixed bridge construction, main supply route repair and construction, and a wide variety of building construction in the theater of operation.

Engineer Officers assigned to these units typically start out as Platoon Leaders, responsible for a platoon from 20 to 45 soldiers. Other jobs include those on staff at the battalion headquarters where an officer may be responsible for unit training, personnel actions, supply operations, or in the case of the Combat Heavy Battalions, may work in the construction office. This office is responsible for organizing the construction efforts of the units, as well as providing technical assistance and ensuring quality control. Most positions that officers hold in these units do not require much formal training as engineers to be effective. The exception to this would be the Heavy Battalion's construction office where civil engineering backgrounds are essential, as well as those positions in this same unit that are responsible for any type of construction. Construction management is an important area for all officers assigned to the Heavy Battalions.

Another field of common assignment includes to that of the Directorate of Engineering and Housing (DEH) where officers are typically assigned to manage the maintenance and repair of existing facilities that fall within the post commander's jurisdiction. The DEH is part of the installation staff, and therefore reports to the installation commander. The DEH is made up primarily of civilian, civil service workers who work in the many operations that fall under the DEH umbrella. These include, but are not limited to carpentry, electrical, roads and grounds,

paint, and planning shops. These shops are headed by civilians, who in turn report to a military officer who heads the DEH. This officer may have one assistant junior officer on larger installations. The large force that these officers control, and the scope of work that the DEH performs requires an engineering masters degree(determined to be a requirement by the army corps) and any knowledge of construction management is very helpful. He should also be a registered engineer as many of his subordinates are. Similar to the navy, the DEH is also responsible for the development of the installation's master plan to ensure that the needs of those tenant units are met as the needs and mission change.

The civil works side has a decidedly smaller officer population than active duty troop units. Army Engineer Officers numbering around 300 coupled with approximately 30,000 civilians are responsible for the development of our Nation's water resources and the operation and maintenance of completed water resource projects. They are also responsible for the development of new construction for any type of government project that may fall within their jurisdiction. These may include such projects as a new post water treatment plant, the construction of a new headquarters or barracks building, or the renovation of motorpools. Officers assigned to these jobs must be engineers by profession, and are generally required to obtain professional registration. Assignments include contract administration,

project inspection, project development, and maintenance inspector. Officers in these fields of work traditionally work with a pool of other professional engineers to develop government contracts from their initial stages through to project completion. Projects include military construction works for both the army and air force and others. Officers in this field of work more often than not have masters degrees in some aspect of engineering and management of construction projects is an important aspect of their jobs.

U.S. NAVY CIVIL ENGINEER CORPS

The Civil Engineer Corps(CEC) is a group of approximately 1600 Naval officers who, with a compliment of 25000 civilian employees make up the Naval Facilities Engineering Command (NAVFAC). NAVFAC is tasked with the planning, programming, construction, maintenance and disposal of all real estate and facilities owned and operated by tne Navy. The CEC has the additional task of directing and managing the forces of the nine active Naval Mobile Construction Battalions (the Seabees).

Positions held by officers in the CEC fall mainly into three broad categories of Public Works, Contract Administration, and Seabee Operations. In the Public Works sector (the largest of the three) the officers are concerned with the dav to dav running of the base. Responsibilities include maintenance and repair of every building, structure, utility, parcel of land, and roadway/runway/railway. He or she assures the water flows, the lights come on, the roads stay open, and the operational forces have all the facility type support they need to carry out their mission. Often in charge of, or second on the totem pole of a department, the military member normally has a staff of personnel numbering from a handful to several hundred. Department personnel range from clerk/tvpists to registered professional engineers to craft journeymen and most areas in between. Most public works organizations employ their own shops personnel to

perform routine maintenance and repair work. Efforts of these shop forces are directed, scheduled, and costs accounted for under the direction of the CEC officer. In order to perform its functions the department has an operating budget that typically exceeds two million dollars for small bases and increases with the facility size. This budget and the accounting for it also come under the purview of the officer.

Other, possibly more important duties call for the individual to look ahead and determine what is in store for his facility five or ten years down the road. In this planning mode the officer assesses the current conditions of all his physical plant account and determines what repairs, replacements, disposals or new construction projects are necessary to support the bases mission. An overall base facilities program (master plan) is established and the proper paperwork generated to justify the separate projects that make up the program. This is the first step in the acquisition process to obtain new facilities. At this point a field headquarters group normally steps in to aid in the quest of acquiring a new building (for example). This group is called an Engineering Field Division (EFD) and is run by other CEC officers with the express purpose of helping the base get what it needs to execute its mission. Funding is always an issue of concern, but for these purposes, suffice it to say that this is a valid project and the navy is willing to pay for it. The EFD will now contract with a design

firm to take the base's requirements (10,000 square feet of additional office space) as developed by the public works department and translate them into a new office building. The EFD normally takes the role of owner/client/CM in relation to the designer with input from the public works officer throughout the design phase. Once the design is complete and the base signs off that this is indeed what they want and need, the EFD takes the plans and specifications and begins the contract bid and award phase.

A Contract Administrator (the second main job category for CEC officers) who works for the EFD is assigned the contract and is in charge of it once awarded. In this role the officer is the government's representative on the job, assuring that the contract is completed on time and within budget. At times carrying out quality assurance tests, coordinating between contractor and base operations, directing the inspection of the work, verifying and approving progress payments, maintaining progress photographs and records, putting together job status reports, and assuring field and customer requested changes are promptly and fairly negotiated and documented, the individual is the navy's main and sometimes sole source of contact with the contractor. Often operating with only a field inspector or two under him or her, the officer may be handling several contracts, each with a value ranging from a few thousand into the tens of millions of dollars.

The military member's supervisor normally operates with a hands off policy allowing the individual to handle the contract and contractor as they see fit (and by the law, of course). Upon completion of the project and closeout of the contract, the facility is turned over to the public works department for upkeep throughout its useful.

The last major category of officer jobs is that of directing the forces of the construction battalions, working with the Seabees. In this capacity the officers operate similarly to a general contracting company. The battalion is given a set of projects to accomplish on its next deployment (no construction works of any significance are performed within the U.S. so as to not displace or replace civilian construction forces with that of the military). Take-off estimates are done on these plans and specifications, for the purpose of ordering materials and planning manpower utilization and requirements schedules. Managing of personnel training programs and schedules along with readying the battalion for its upcoming deployment is the responsibility of the officer while in home port.

Upon deployment the Seabee's purpose in life becomes readily apparent. Constructing everything from single hole outhouses to twelve thousand foot runways, to power plants and water treatment facilities, the Seabees are more at home on deployment than in home port (and usually a bit less trouble too). The officers now

are managing the efforts of this, their work force. They have been given a job to do and the materials and manpower with which to do it. Left now to their own devices and an optimistic progress schedule generated while in home port, their task is to do all the work scheduled and as much more work as material and time permit before the deployment cycle is up. This is a unique and challenging job that most CEC officers agree is the best job in the Navy.

U. S. AIR FORCE ENGINEERING AND SERVICES

The following is paraphrased from the U.S. Air Force's Civil Engineering Career Development Brochure.

The justification for military engineering forces is to support contingency (wartime) operations. It may call for the individual to provide engineering support anywhere in the world, on short notice, and possibly in a hostile environment. This requires detailed pre-planning, constant readiness to move quickly, and frequent training in how to provide facilities and services expediently.

The Base Civil Engineer(BCE) is the "city engineer" for his base. Everyone on the base relies on Civil Engineering housing, community services, utilities, the work environment, and the recreation environment. All the facilities that support the mission: the runway, airfield lighting, fuel and munitions storage, roadways, and passive defenses are the singular responsibility of Civil Engineering.

The Base Civil Engineer and his staff are charged with managing annual operations and maintenance budgets averaging $10 million, fleets of about 100 vehicles, up to 1,000 employees, and the logistics system to support this work force. The unit is typically one of the largest on the base and the one that is

responsible for management of the largest single percentage of base resources. Some of the significant management responsibilities include: Advising on financial matters, participating in most contracts, Acting as focal point for facility use and planning, Participating in regional, state, and federal energy and environmental programs.

Types of work the Air Force civil engineer can expect to be involved with include: engineering design, management of contracts, design management, development of management systems, training in combat arms, management of funds, materials, equipment, command of military organizations, directing large work forces, operation and maintenance of utility systems, energy management, environmental planning, supporting the flying mission, research and development as affects civil engineering, contingency design, construction (Red Horse Squadron), equipment management, housing management, base maintenance management, program planning and development, and construction program management. Although this is not an all inclusive list of works performed by the Air Force civil engineer, it will serve as a good indicator of what functions the member is tasked with and therefore what skills are appropriate for him or her to acquire.

APPLICABILITY ASSESSMENT

With all the previously mentioned functions and tasks of the civil engineers in the military, Their need for a Construction Engineering and Management program is readily apparent. Each service possesses its own construction or repair force directed by the officers in its civil engineering group. In this role the officers plan, direct, manage, and control construction forces much the same way a general contractor would in the private sector. Unlike their civilian counterparts, the military organizations are not in business to make money. But the tax payers should be assured that the defense dollars are spent in the most efficient manner possible. One avenue to assure this, is to make sure that those in charge of the funds are as highly trained and educated as possible in their respective fields. The individuals should, at the very least, be keeping even with their peers in the private sector to be certain that the government's interests are well-served.

Not only in the position of directing their own military forces is this advanced educational program valuable to the officer. In the billets in charge of base maintenance and repair the individual needs to know at least the basics in accounting and cost control, personnel management and human relations, and estimating and shop scheduling. The job of contract administrator is no less of a draw on the officer's knowledge and

capabilities. Normally handling numerous contracts for the government, the member needs a good background in construction contract law, bargaining and negotiating, scheduling and accounting practices as well as disputes resolution methods and a wide array of other topics.

In short, the officers can use almost every topic available in the curriculum of the Construction Engineering and Management programs investigated by the author. The military services have realized this and responded by sending between thirty and fifty officers each year to any of a number of construction programs. One contracting methodology is particularly pertinent to the functions of the military civil engineer and is explained in detail in the next chapter, Construction Management.

The author attempted to discover the process with which the institutions and their programs were evaluated by the military service and then authorized for use by the officer in pursuit of an advanced degree. None of the services could provide a fixed, bottom line set of criteria required of an institution for use. Noting this apparent lack of an evaluation system to compare institutions and programs, one was developed after an extensive survey of senior officers and research into the contents of available graduate programs (see Program Comparison).

Construction Management System

One delivery system within the realm of Construction Engineering and Management has arisen in the past two decades and has received enough attention to warrant its own separate discussion and evaluation. The system is that of Construction Management(CM) or as it is sometimes referred to Professional Construction Management(PCM). This method is defined below and a comparison is made as to its applicability to the military needs.

The use of "construction management" as an approach to accomplishing construction projects has been employed since the 1960's with a few accounts of the system dating into the mid 1950's. The CM approach was originally developed due to the increasing scope and complexity of both project planning and execution. Summed up in a one line description, the construction management system deals with the total process of delivering a complete project. To further clarify what the Professional Construction Management system is, we turn to the American Society of Civil Engineers' Task Committee on Management of Construction Projects. The Task Committee developed the following definitions:

Professional Construction Management - Professional Construction Management is one effective way of satisfying an owner's construction needs. It treats

the project planning, design, and construction as integrated tasks. Tasks are assigned to a project management team consisting of the owner, the construction manager, and the design organization. A prime contractor or funding agency, or both, may also be a member of the team. The team works together from the beginning of design to the project completion, with the common objective of best serving the owner's interests. Contractual relationships between members of the team are intended to minimize adversary relationships and contribute to greater responsiveness within the management group. Interactions between construction cost, environmental impact, quality, and the completion schedule are carefully examined by the team so that a project of maximum value to the owner is realized in the most economic time frame.

Professional Construction Manager - A Professional Construction Manager is a firm or organization specializing in the practice of construction management or practicing it on a particular project as part of a project management team consisting of an owner, a design organization, and Construction Manager(CM). A prime construction contractor or funding agency, or both may also be a member of the team. As the primary construction professional on the project management

team, the Construction Manager provides the following services, or such a portion thereof, as may be appropriate to the specific project in question.

1) The CM works with the owner and the design organization from the beginning of design through completion of construction, providing leadership to the construction team on all matters relating to construction, keeping the project management team informed, and making recommendations on design improvements, construction technology, schedules, and construction economies.

2) The CM proposes construction and design alternatives to be studied by the project management team during the planning phase and analyzes the effects of these alternatives on the project schedule and budget.

3) Once the project budget, schedule, and quality requirements have been established, the CM monitors subsequent development of the project in order that those targets are not exceeded without the knowledge of the owner.

4) The CM advises on and coordinates procurement of material and equipment, and work of all construction

contractors; may monitor payments to contractors, changes, claims, and inspection for conformance to design requirements; provides current cost and progress information as the work proceeds; and performs other construction-related services as required by the owner[Barrie76].

These definitions are by no means hard and fast rules to which all systems claiming to be construction management are compared. But they are a guidepost or starting point in understanding this contracting methodology, an initial look at the interrelationship of the members on the owner's team.

As a key member of the team, the Professional Construction Manager's function is to plan, administer, and control the owner's overall construction program in a manner best suited for the project's objectives. These objectives, as dictated by the owner, usually include on time completion, minimal cost while maintaining desired quality and function, plus adherence to owner administrative and control requirements.

In execution of his tasks the CM has responsibilities to various persons and groups involved in the project. Most obvious is the professional and reliable advice and guidance given the owner, free from distress of economic reprisal. Often seen as the overall project director, the construction manager also

should know and keep the owner informed of the current status of the project and how it compares with the execution plan.

Responsibility to the designer through a professional relationship is the key to taking advantage of value engineering in the design phase. The CM, through his thorough economic knowledge of construction, should augment and enhance the capabilities of the designer in reducing the overall project cost for the owner. Reductions should be worked for, accomplished, and taken credit for as a team in an effort to advance the standing of both the designer and the CM in the owner's mind. With an eye toward accomplishing the owner's objectives as a team, the CM needs to have a valuable partner in the designer.

The contractors on the project look to the Construction Manager for faithful and unbiased reading of the plans and specifications. The CM is therefore responsible to determine a reasonable interpretation and if the plans and specifications are found to be in error or ambiguous, he or she should assist in getting appropriate additional compensation to cover the additional costs. The CM must also insist on just compensation for any change or modification initiated by the owner or designer. With equal zeal the contractors must be required to provide proper materials and workmanship to comply with the contract documents.

Other groups to which the CM has a professional responsibility are union and other labor organizations. Collective bargaining agreements must be recognized and worked within the bounds of. Locally practiced craft jurisdiction should be researched to obtain a working knowledge of accepted boundaries as well as grey areas of which to be wary.

Activities normally performed by the CM reach far beyond those typically accomplished by general contractors. The bulk of the difference is found in the planning stages of the entire project. Commonly brought in after the owner and his/her design agent have firmed up a general scope, the construction manager becomes an integral member of the team before detailed design is begun.

Initial planning is the cornerstone in the successful execution of any project. For the CM this process begins with an investigation into the owner's objectives and requirements. Information that must be researched or obtained includes: When must the project be completed? Are there any intermediate project milestones to be met to fulfill owner commitments? Are any other schedule requirements available or additional schedule information known at this time? What is the initial cost estimate and what constraints are imposed on the budget? What is the present design and what are the desired specifications? Are there any preferred methods of construction? What are the

owner's requirements/desires for bidder qualification, bonding, and other internal procedures? What are the responsibilities of each member of the team and to what extent is their authority? What functions will the owner perform in-house and what additional services may be required? Who are the key players responsible for the actions required by the designer, the owner, and the CM?

Continuing on to the next key player, the CM must establish the groundwork between himself/herself and the designer. He or she must continue to collect and review data on the design criteria, conceptual planning, and design work to date. The preliminary design schedule should be reviewed or generated in order to aid phasing of the project program. A value engineering philosophy and program should be initiated or developed to enhance the relationship between the owner, designer,and CM. The designer's knowledge of both the proposed site and relative jobsite construction economic factors should be determined. The desired final completion criteria should be confirmed and a preliminary design schedule to meet these dates should be agreed upon. Specific roles and responsibilities to the owner and to each other should be established by the designer and construction manager. The authority delegated to each key player needs to be confirmed and the responsibilities of designated individuals in each organization should be defined.

The remaining investigative work to be performed is on the construction jobsite and around its local area. Existing conditions at the actual site are a must to verify. A look into the local work practices and craft jurisdictions along with trade productivity and availability can prevent numerous problems later on. Collective bargaining agreements should be researched and understood. Local expertise in materials and practices may be helpful in value engineering possibilities as could knowing local prices for standard items. Weather information is required for scheduling considerations. Capabilities and current/projected workload of local contractors should be investigated. Permit requirements, zoning and local agency jurisdiction must be realized and the proper steps initiated to assure all requirements are satisfied for the project to continue from start to finish.

From all the information obtained, a Project Plan is drafted and finalized by the CM with the concurrence of both the designer and the owner. The final plan would include the categories of: 1. Project approach, 2. Office services of each key player, 3. Site services to be provided, 4. List of work packages and their design schedule, 5. Package procurement schedule and overall project CPM, 6. Implement value engineering program, 7. Finalize project control procedures, 8. Assign key duties and establish standard procedures for completing tasks and reporting. Upon completion of the project plan and as design packages bid

document quality, the CM turns to the execution stage of the project. This stage is made up of two phases: a) Bid and Award phase, and b) Construction phase. Work to be accomplished in the bid and award phase includes: 1. compile bidders' lists of qualified contractors for each package, 2. prepare, review and issue bid packages with request for quotation, 3.assure a detailed and accurate cost estimate is made for each package, 4. receive, review, and analyze bids, 5. recommend contract awards, and 6. issue "Notices to Proceed".

Operating in concert with the bid and award phase will be the construction phase. Herein the CM's responsibilities parallel, with a few exceptions, the traditionally accepted role of a general contractor beginning with the establishment of the field office. Other functions include: 1. arranging for testing services and site layout, 2. obtaining required permits, 3. managing, coordinating, and inspecting the work of all contractors, 4. maintaining job diaries, as built drawings, and other pertinent documentation, 5. preparing and approving progress payment invoices, 6. keeping progress photographs and records, 7. accomplishing input for project control system, 8. preparing desired reports, and 9. preparing acceptance and closeout documents[BARRIE 1976].

COMPARISON TO MILITARY CIVIL ENGINEERS

What parallels, if any, are seen between the functions and responsibilities of the Construction Manager and those of the Armed Forces civil engineering groups? Due to the writers affiliation, the key words and titles in this segment will reflect those used by the U.S. Navy. Each of the Navy's Civil Engineer Corps' counterparts, in the other services, performs more or less the same functions therefore only one comparison will be developed.

The Navy is a sizeable "business" and property owner with many and varied mission requirements throughout the world. In order to perform its ever evolving mission the Navy has an overall program of "acquisition" that enables it to attain its goals. This acquisition system entails many aspects, but for this paper our focus will be directed on the facilities segment. For clarification, let us use an example of a Naval Station tasked with the homeporting of a newly commissioned battleship and her battle group. Surveying the existing facilities, we find that the length of existing pier is insufficient to berth the battleship itself let alone the entire squadron. This is an owner, with a project, in need of some expertise in the planning and execution of a facilities program. The CEC Officer, in some capacity, is usually involved to a greater degree than the Construction Manager in that the military member is tasked with

determining the total scope of facilities required. In comparing the requirements determined above with the existing assets, deficiencies are noted and a program of additional facility needs generated. Once the needs are identified, avenues to correct the deficiencies are researched and new construction is often the selected course.

A design firm is normally brought aboard at this point to accomplish the design and prepare bid documents with the assistance of the officer as the owner's representative and modified Construction Manager. The officer knows well the objectives and requirements for the program and each individual project within. Project completion requirements, program milestones, cost estimates, budget constraints and the like are all near and dear to the heart(s) of the CEC representative(s) on the project. Desired specifications, unique conditions, and bidder qualification are all within his or her realm and jurisdiction.

In conjunction with the design firm, a design schedule is determined and a value engineering program implemented. Field expertise is provided by the officers due to their knowledge of what is economically available and cost effective to maintain. (Knowledge the officer has is often obtained through experience in a Public Works capacity early in his or her career) For the construction phase of the project, roles and responsibilities are

often dictated by the Navy in its contract language. But a fair amount of latitude is given to the administering officer within the scope of the contract.

The investigative work performed by the CM closely parallels that of the Resident Officer in Charge of Construction (ROICC) office. Handling construction contracts in a ROICC capacity as a contract administrator, the CEC officer knows the construction site and the surrounding area. He or she is versed in local contractor capability, work practices, trade productivity and availability. Permits, zoning, and other jurisdictions are normally coordinated by the ROICC office due to the work being on located federal property.

Through the entire construction program, from owner requirements to final acceptance and closeout documents, a Civil Engineer Corps officer, in one capacity or another (not necessarily the same individual), is performing the tasks previously described as those of a Professional Construction Manager. The tasks are accomplished in a professional manner with responsibilities to the government i.e. the taxpayers, to the designer, to the contractors and any other groups involved in the program or project.

The system is not without its differences from what the military civil engineer uses on a day to day basis. CM tends to

involve itself more extensively in project controls than is normally required by the officers. The development and use of simulation and modeling, though very interesting and applicable in certain areas, does not lend itself to the work carried on by the military engineers (the groups focused on in this paper).

With the above described functions and tasking of the Professional Construction Manager and its multitude of similarities with those of the Civil Engineer Corps officers, the writer sees a definite value, and better termed a need, for military members to seek out and utilize those construction engineering and management programs that emphasize the construction management method of project delivery. With the one stipulation that those courses mentioned above not be required, but be offered as electives to allow the officer the choice of exposure to these subjects or others that he or she may feel more pertinent to his or her situation.

VIEWS FROM SENIOR OFFICERS

The writer conducted a survey of senior Navy Civil Engineer Corps officers to determine the applicability of a Construction Engineering and Management masters degree as seen by upper management. The seventy-four individuals polled were of commander and captain rank (O-5 and O-6) and averaged over twenty years of active duty service. The officers were surveyed via telephone conversations and asked questions about a graduate Construction Engineering and Management program's pertinence and possible application to their positions both past and present. They were also asked their opinion of the Navy's post graduate school program as to what was good, bad, or indifferent in it. This survey was not of the yes, no, check the block type questionnaire (see Figure 1. - Appendix A) therefore no "hard" statistics will be quoted. Its purpose was to ascertain if those in the upper links of the chain of command felt that this type of curriculum was beneficial to military officers and what areas of study, if any, should be concentrated upon. Following are the results of that survey.

All of the individuals polled had completed graduate degrees through the Navy's post graduate school program. Over half of the respondents had been in Construction Engineering and Management programs from various universities around the country. Other graduate programs attended by the officers included

financial management, urban planning, public works administration, mechanical engineering, petroleum engineering, ocean engineering, electrical engineering, structures, pavement, and general civil engineering.

The majority of those queried reported that they believed Construction Engineering and Management to be one of the most useful curricula available to military civil engineers. Of particular appeal was the program's broad coverage of many varied topics. This wide range allowed the one, most often stated quality, desired in a graduate program, that of letting the student pursue his or her own personal preference in educational objectives. None of the CE&M programs completed by those polled were so regimented that the individual could not follow at least a portion of their own desires while completing the variety of courses required by the school program's core curriculum. For those completing the CE&M programs, the use of the broad-based curriculum enabled them to become conversant in several areas dealt with frequently on the job such as accounting, personnel management, scheduling, and construction costs & estimating.

The most agreed upon view of those officers who had completed more technical graduate degree programs was that they did not employ that knowledge gained on a daily basis, if at all. This is not to say that their advanced education has been a waste of time and money. With the Armed Forces mission to be prepared

in time of conflict, the writer can think of no more appropriate person to be in charge of the electrical utilities than someone with an advanced degree in power distribution or a pavement masters degree holder in charge of road and runway repairs, etc. For an optimum near term return on educational dollars, it appears that a solely technical program is not the desired course. All officers agreed with the need to have some form of management training or instruction. Most felt it appropriate to take graduate level courses in this area, while a few believed it more beneficial to get military specific instruction for the topic elsewhere.

The big picture management process was stressed by the most senior of those surveyed, the captains in particular. Their generalized feelings were that as officers they manage the three M's, manpower, material, and money. With this in mind, the specific topics of financial and personnel management were deemed quite desireable to cover while in school. People-oriented courses were a topic many officers said that they could not get enough of or ever be too knowledgeable in that particular area. One individual's example on the possible return on people topics as opposed to numbers courses was that he could save a small but appreciable percentage on construction costs by a thorough review of the plans and specifications and implementation of value engineering methods. On a large job, that same percentage of savings could be consumed within one week if a strike were to

occur that could have been avoided. His conclusion was that a labor relations or union negotiation course could be much more beneficial in the long run than the value engineering topic that could have been learned on one's own time with a good book anyway.

Looking at the broad category of "acquisition" and realizing that the military civil engineer's role deals mostly with facilities for each of the services, a few officers noted that the educational need may best be satisfied by programs that zero in on the project delivery system termed "Construction Management". Their logic appeared to be that this system, more than most others, involved the individual or group (termed the Professional Construction Manager) through out the entire sequence of the project or construction program. This aligned more closely with the mission of the Civil Engineer Corps in being the overall facilities director for the Navy.

An interesting side note from the officers completing programs other than CE&M was that most had either taken or intended to take one or more courses recommended or required of the construction program (where available).

A major portion of the respondents expressed a preference for taking more course work rather than completing a thesis or even a major research report. Their rationale was that, as

officers, the more exposure to a wider variety of material was better use of their time than researching and compiling a report (often what they do in their jobs on a lesser scale). Again the idea of personal preference was stressed and if any individual had a specific interest or desire in an area, whether directly beneficial to the government or not, he or she should be allowed to pursue that desire.

Another common perception shared by most of those polled was that the twelve month alloted time period was not long enough to complete a program and get the most out of it. One officer's feeling was that he had survived the ordeal in his alloted time frame but now he really would like to return to school and have a chance to learn something. Often used descriptions of the twelve month alloted period to complete the program were cramped, tight, inappropriate, and frustrating. Many graduates found, as is common today, that schedule conflicts eliminated the opportunity to take a whole host of courses that would be pertinent and beneficial and that many courses were only offered in one particular quarter or semester.

When asked about their overall satisfaction with regards to the graduate school experience, of all the officers surveyed only one had a negative impression and reported that the time at school had not been worth the time away from the office (The individual had not been enrolled in a CE&M program). One officer

who did enjoy the overall experience questioned whether or not it was worth losing an officer for one full year or more given that a complete career in the military can end at twenty years of service (the old retirement system anyway).

A brief explanation of the advanced education program for the military is in order at this point. Each service has its own graduate education program through which it sends a number of officers back to school to obtain advanced degrees each year. In this program the officer is ordered to a university for one to two years of study to obtain the degree for which he or she has been approved. During this time at school, the officer is on full salary and the tuition is paid for by the government. Upon completion of a curriculum, normally twelve to eighteen months later, the military member then owes the government additional service time. The common payback is three years of service for the first twelve months of school and a month for month commitment for any time in excess of twelve months.

With the funding of advanced education for officers in the civil engineer groups of the Army, Navy, and Air Force, the government fills basic mission requirements of each service. Beyond these direct tangible basics, the fully funded graduate programs accomplish much more. From the writer's point of view and that of the officers polled, each service realizes a higher return on its investment through the indirect benefits than could

ever be made in any other affordable manner. The following is a listing of indirect benefits compiled during the author's research.

The most obvious plus, from the services point of view, is the retention factor. Looking beyond the payback period of "required additional service time", most officers are instilled with a feeling of commitment made on the part of the service to further advance the individual and his or her career. This vote of confidence can go a long way in an attempt to correct the disparity in compensation between the military officer and a civilian counterpart. For many officers their required additional service time takes them past the point of ten years of active service. Here the individual often feels it is worth sticking around for another ten years in order to retire with a pension.

A related, but much more subtle factor the advanced education programs have is in the recruiting area. Most of the top notch, newly-graduated engineers of today realize the pace with which the engineering fields are expanding. To keep abreast of the most current developments takes more time than the work-a-day engineer has to give. Evening courses for an advanced degree are expensive, time consuming, and requirements for program completion can take up to ten years for part time students. Few companies offer any combination of: time off for

full course loads with no concurrent job related responsibilities, full salary while attending school, and full tuition coverage. The writer has found each benefit available by itself from various companies and modified, limited combinations of some, but never were all three offered simultaneously (With enough effort an exception could be found but its existence is definitely not the rule). For a chance to cash in on a program such as this, many engineers are happy to work in the field for four to six years before returning to graduate school (It also gives them a chance to see if military life is really for them or not before incurring any additional obligation). Not only does this give the officer a better perspective on what is important on the job and therefore in the classroom, it also allows him or her to bring back lessons learned or situations encountered to share with classmates and instructors to prove or question theories explored in their course work.

Most officers, as they advance up the ladder, begin to work more and more with professionals and public officials. In working with a design firm on a project estimated to cost millions of dollars, the military member will be interacting with registered architects and professional engineers on all aspects of the work. His or her knowledge must equal these contemporaries if the government is to get the most for its military construction dollar. With controversial projects such as new facilities for the home porting of nuclear powered

vessels, the officer may be dealing with mayors, governors or congressmen and their constituents. Each party is concerned with a different aspect of the project, from the increase in job opportunity, to the increased capacity required in the public school system to support military families that will be moving into the area, to the environmental impact of the new construction projects. Therefore credibility and professionalism are desired for the individual dealing with these situations. Post graduate education is one of a handful of factors that can weigh heavy in enhancing the members standing in the eyes of those with whom he or she deals.

The work-a-day civil engineer officer is, in most cases, away from the design table and deals little with the actual number crunching calculations other than occasionally checking or questioning a figure or two. Therefore time in post graduate school allows the individual to dig out the steel manual or other appropriate reference books and brush up on the how to's of design.

The significance here lies with another of the career enhancing factors, i.e. obtaining a Professional Engineer's License. This accomplishment is taken none too lightly by any of the services and is becoming an increasingly important milestone in the road to upper management (Whether in the service or out in the private sector). The elective course work for their masters

degree should be viewed by the officer as a chance to further his or her knowledge yet provide a good ground work for the taking of the professional engineer's exam.

Another plus for the civilian education program is the opportunity for the military member to go on a sabbatical from the service. Though never totally out of contact with the military, it refreshes the officer to be able to choose what to wear to work (class) and determine how his or her schedule is to be arranged. It allows them a year away from a ringing phone and the myriad of job related "fires" that need to be doused immediately.

The individual has the chance to catch up on much of the latest technology and to investigate the state of the art in his or her area of interest. A new, fresh, educated view is commonly developed during a tour at a civilian institution. The officer gets the opportunity to interact with civilian engineers as well as members of other services and is exposed to different ideas, techniques, methods, and solutions to similar problems. All of this exposure contributes toward making the civil engineer officer more well-rounded and qualified to take on the responsibilities of higher rank and authority.

Program Comparison

Up to now Construction Engineering and Management(CE&M) history, institution and industry desires, and the Army, Navy, and Air Force civil engineering group's functions and tasks have been explored. Applicability of the CE&M program from both the writer's comparison as well as a survey of senior Navy officers has been presented. Numerous universities around the country offer a variety of programs. But which is more advantageous to the needs of the services? Below is the author's evaluation system and a listing of institutions, in order of rank, employing that system's criteria. Thirty institutions were selected for evaluation. Selection was based on the school's offering a masters degree in Construction Engineering and Management and its having an ABET accredited undergraduate curriculum in the sponsoring department or college. Twenty of the schools contacted responded and provided the information requested.

Discussion and rationale of each parameter used in the author's evaluation system is listed. Following is a discussion of the scale, weight factor, and criteria used to score each of the separate factors. Concluding the chapter is the listing of how each school measured up.

PARAMETERS - Discussion and Rationale

1. Accreditation - Although there is not currently an accreditation system for graduate programs in Construction Engineering or Construction Management, the diverse mix of backgrounds of individual officers from the different services sometimes necessitates the completion of undergraduate degree requirements before continuing on for a masters degree. Although this need is the exception rather than the rule, the capability to obtain an undergraduate degree that will be accepted when applying for professional registration is a prominent factor. More importantly, the existence of a program accepted by the Accreditation Board for Engineering and Technology indicates a firm commitment on the part of the university to provide a rigorous and balanced education covering the "basic principles" engineering concept.

Professional registration is not an event to be taken lightly by an officer of any service. With advances in rank come positions of increased authority and supervisory responsibilities over both licensed engineers employed directly by the government and design firms contracted with for the performance of project design. Senior officers are often called upon to sign drawings as both a government representative and a professional engineer. Many of the most desireable jobs can be filled only with by an officer with his or her Professional Engineering license.

2. Prestige - Perhaps not as important a parameter yet still a definite point to be considered is the prestige of the institution. Tied directly to this issue and inseparable from it, is the quality of the programs offered. Only with a quality program enhanced by a well-regarded faculty can a university produce notable graduates to establish an honored reputation.

3. Well-known Faculty - Just as film makers often attempt to feature a well-known celebrity to draw in the public, so can an institution utilize the same ploy. An acknowledged leader in the field of Construction Engineering and Management is often a sign of a progressive program and the institution's dedication to providing a state of the art education. A majority of the highly-regarded curricula are centered around a single individual and most often guided by their leadership.

4. Diversity of Faculty - Variety in background and areas of expertise among the faculty and staff supporting the Construction Engineering and Management program is a desireable characteristic. The need to expose students to both the classroom theory and research, as well as to actual real life job experiences from an individual who has been there, cannot be overemphasized.

5. Faculty and Student Population - This parameter is composed of three sub-categories: a) Number of Faculty, b) Number of Students, c) Student to Faculty Ratio.

a) Number of Faculty - The number of faculty in a Construction Engineering and Management program is not to be viewed entirely on its own. The number of students along with student to faculty ratio (both discussed later) are highly interrelated aspects, the combination of which should be examined as a whole. Evaluating this parameter as a single entity we find that one individual is not normally sufficient to cover the length, breadth, and depth of the wide range of topics covered in a construction engineering curriculum. On the opposite end of the spectrum, a compliment of five or more faculty members may add variety in approach and diversity in opinion plus cover many more topic areas. The average military officer completes the masters program in twelve to eighteen months and more than likely would not be afforded the opportunity to take all the courses a large faculty could offer, although it is still considered a definite advantage.

b) Number of Students - This figure can be an enhancement or a detraction at either end of the scale.

If the student enrollment is held to a minimum, with a constant number of faculty, the student benefits by having smaller classes with an opportunity for a good amount of one on one interface with the instructors. It also affords the individual's advisor the chance to get to know his or her charges personally. This would allow the student and teacher to design a more unique program of study to fit the advisee's desires and motivations. It would also enable the faculty member to more closely supervise and direct the student's research efforts.

From the other side of the fence, a smaller group does not introduce the variety into class discussions. It lacks the breadth of experience offered by a class made up of individuals from many backgrounds and degrees of experience. A larger group also affords an opportunity for the faculty member to direct research in a wide number of areas at once and build upon that base with successive classes of students.

c) Student to Faculty Ratio - Certainly a major consideration, and obviously tied to the number of both student and faculty is the student/faculty ratio. This advisee/advisor parameter can give the prospective student an indication as to whether he or she will be viewed as an individual with goals, desires, and

capabilities or as another number to be input, processed, and rubber-stamped on the way out.

It is recognized that institutions walk a fine line in this area, attempting to maintain a quality program yet accommodate their fair share of the multitudes of students that apply for admission each year.

6. Entrance Requirements - Entrance requirements are another of the two edged swords in rating schools. It was Woody Allen who said "I'd never want to be a part of a group that would have me as a member". The same is true at times with admission policies. Grade point averages of undergraduate coursework remain a good indicator of how an individual will perform in graduate school, but this is not the only factor. The type of undergraduate degree held by an applicant is definitely an important factor in assuring that basic principles will be common knowledge to all masters degree candidates. Yet the flexibility to allow individuals of diverse backgrounds to attempt a program should be considered. After all, are we each doing what we are best at or have we just not found our specialty yet?

A single test such as the Graduate Record Examination is also a popular channel marker for those navigating the seas of higher education, yet does one test a good engineer make? As with the Professional Engineer's exam, I'm sure every engineer

who swells with pride every time he or she affixes their seal on a document can name at least one colleague who doesn't deserve to wear the title of Professional Engineer but does so anyway. Positions held, responsibilities undertaken, supervisors opinion's, and overall competence should be items considered in the selection of prospective masters degree candidates. The military, in its own selection processes, has theoretically weeded out the non-performers and is hopefully offering to send only those officers with a desire to learn and the capacity to finish a program once it has been begun.

7. Tuition Cost - Cost may not be the most important parameter, but is certainly one of the most sensitive, and rightfully so as the tuition for the attending officer is paid with public funds. As with most commodities, you get what you pay for and only purchase what you can afford. Graduate programs of similar caliber tend to be comparable in price, at least in state supported institutions. For the officer, his or her home of record could be a deciding factor of which school to attend. With other factors being equal, the possibility of the officer taking advantage of in state tuition and saving the government a considerable amount of money is attractive (not to mention the chance for the individual to be close to family and old friends in many cases).

8. Institution Location - Realizing that schools are not about to relocate to cater to any one particular group's needs, this category on the surface seems to be a moot point. With a more in depth look the factor begins to make more sense. The Armed Forces have well-established bases and posts throughout the United States. Many of these facilities are located in or near highly populated areas boasting desireable institutions with worthwhile Construction Engineering and Management programs.

Although it may screen out some universities with otherwise exceptional programs, the fact remains that it is more cost effective for the service to order an individual into an area where he or she could receive a follow on tour. Instead of moving an officer to a school for eighteen months or less and then relocating them again after graduation, the individual could be assigned a local billet before or after graduate school and become a semi-permanent member of the community.

9. Officer Opinion - Looking from the point of view that you can never adequately judge something until you have experienced it, the feedback from individuals completing a program is a major determining factor in school ranking. Care must be taken to assure the information provided is as unbiased as possible in order to responsibly evaluate a program. Ill feelings over one course or an administrative hassle can skew an officer's point of view and possibly black ball an otherwise outstanding institution. Realizing the advances and almost constant changes

in program content and supporting faculty, feedback needs to be current. In some instances the feedback of an officer attending two years prior could possibly be totally incorrect and not indicative of the existing conditions. Yes, there is a problem with this parameter in that officers are not presently attending each university with an appropriate curriculum and therefore an unfair advantage exists for those schools with officers currently enrolled. This factor should not and cannot be negated due to this inconsistency (adjustment is explained in the criteria section).

10. Program Versatility - This parameter is composed of five sub-categories: a) Thesis Option, b) Base/Core Curriculum, c) Electives, d) Program Length, and e) Industry Consciousness.

a) Thesis Option - The overwhelming majority of senior officers interviewed in the author's poll stated that they had pursued the non-thesis option in their graduate school program (if available). The same majority believed the average officer would be better served by the exposure to additional coursework normally required by a non-thesis option. The almost unanimous viewpoint was that the option should be left to the individual officer. Anyone with a definite interest in the research of a particular topic, whether directly job related or not, should be allowed to

pursue his or her desire so as to provide maximum satisfaction with the graduate school experience along with advancing the state of research and development. Therefore a Construction Engineering and Management program that offers a choice between the thesis and non-thesis option, or another alternative option is preferable to that of a program with only one avenue to its degree.

b) Base/Core Curriculum - Although all knowledge obtained has some value, the author sees a need to standardize at least a base or core curriculum. Due to the variety of capacities in which all of the military civil engineer officers will serve, each service should develop its own set of required courses. This cannot be the primary concern of the educational institutions. However, after each service has determined its base curriculum, it can be measured against that offered by the school to determine if the service requirements can be accomplished, under a given curriculum, by an individual, within a limited time frame at that particular institution.

c) Electives - Once the requirements for both the service and the school have been determined and satisfied, attention can be turned to electives. A

wide range of both technical civil engineering courses and related support courses is desired. The technical topics accomplish two main objectives in that they allow the officer to either catch up with or initially explore the state of the art in a particular area of interest be it pavement design, structures, soil mechanics, terrain evaluation, pollution abatement, etc. These courses also allow the individual a chance to get back to the number crunching design world to brush up on his or her skills to ready himself or herself to take the Professional Engineers Licensing examination. Neither of these accomplishments is often possible in the work a day world of the civil engineer in the armed forces.

Related support courses have an extremely wide range and should be left up to the student, the advisor, and whoever is approving the officer's educational plan. Desireable topics may come from other departments or colleges within the institution itself. Subjects may include business law, labor relations, marketing, operations research, business psychology, or any other topic the officer can demonstrate to have a direct relationship to his or her continuing career.

Acceptability of transfer credits from other universities as well as credit for undergraduate

courses from within its own system play a role in the elective's rating as set up by the author. Due to the transient nature of the officer's duty assignments, many individuals have begun work toward a masters degree on their own time but have not yet finished. This work, if applicable, should not be totally negated forcing the student to start over from square one. Undergraduate courses might also be appropriate to fill gaps in the military member's background or simply bring him or her up to speed in a specific area, e.g. Computer Applications for Civil Engineers for the computer illiterate.

d) Program Length - Most programs currently offered range in duration from a minimum of nine months to an indefinite number of years, depending on the individual's situation and approved extensions. The officers completing the programs are given an average of nine to twelve months for the Navy, fifteen to eighteen months for the Army, and about fifteen to eighteen months for the Air Force also (depending on the school year system). Each service has its own exceptions but rarely do any of them allow twenty-four months or more for the masters degree completion. This parameter evaluation must be done on the program offered and its versatility. Due to operational

commitments, officers cannot always begin during the fall quarter or semester. Therefore the requirement of prerequisites must be explored and the flexibility of the program determined. The most desireable curriculum is one that allows students to start at any time during the academic year and finish within the time frame allcted without paying the price of a lop sided schedule.

e) Industry Consciousness - The institution, where possible, needs to tap into and make full use of the locally available or regionally obtainable industry talent. Lecture seminars drawing noted professionals, or better yet full courses taught by those currently practicing in the real world what is being preached by the faculty can enhance a program as much as any other factor noted. The program curricula need also be responsive to the current trends seen in industry. An example of this is the increase in litigation due to the claims on construction projects. Because of the now common practice of installing lawyers at sixteen inches on center around a construction site, most programs have developed and included one or more courses on construction law,negotiation, avoidance of contract disputes and the like.

Once the factors or parameters had been determined an

appropriate scale, weight factor, and scoring criteria needed to be determined in order to evaluate the programs as unbiasedly as possible. Below are those developed by the author.

PARAMETERS - Scale, Weight Factor, and Criteria

1. Accreditation - scale: yes or no

Weight factor: A 100% factor is tied to this parameter.

Criteria: If the institution does not have an ABET accredited engineering undergraduate curriculum for the department or college in which the Construction Engineering and Management program is offered, the school should not be considered as a potential source of advanced education for officers. Only in extreme circumstances should the waiving of this requirement even be considered.

2. Prestige - scale: 0 to 10

Weight factor: 6/100

Criteria: Admittedly a subjective factor this parameter carries relatively little weight. Yet well-regarded schools such as M.I.T. and Stanford deserve their due as leaders in the field and should be the yardstick against which others are judged. The author chose to use The Gourman Report[Gourman83] graduate school rating guide as a baseline. The top forty-five engineering schools are listed in the guide in order of rank. The list was divided into nine equal segments of five schools each. Scores

were then assigned to each segment with score of ten given to the first section, the schools ranked one to five, and decreasing one for each successive section until reaching a two for the last group. Those schools not included in the ranking were given one point for this category.

3. Well-known Faculty - scale: 0 to 10

Weight factor: 5/100

Criteria: Another somewhat subjective factor is having an acknowledged leader in the field of Construction Engineering and Management on the faculty. It is agreed that not every school can have such an individual but those institutions that have obtained or retained professors in this category deserve credit. The program was given a ten if two or more of the faculty were instantly recognized due to authorship of textbooks, published articles, research projects, or other related works and the rest of the supporting faculty were PhD holders. A zero for this category was obtained by having all little known instructors with few to no publications, and no faculty member possessing a Phd or having extensive work-related experience, i.e. an ex-corporate officer for an ENR Top 500 Construction Firm / Top 400 Design Firm with CM expertise.

4. Diversity of Faculty - scale: 1 to 10

Weight factor: 8/100

Criteria: This parameter is fairly indicative of the

institutions approach to the curriculum. It is also not significantly dependant on shear number of professors and assistant professors in a program. A department with as few as two instructors could cover the realm from industry wise construction executive to theory dependant researcher. On the author's scale a ten was given to those universities having faculty on both ends of the spectrum with each an acknowledged expert in his or her area. A one was awarded to the school with faculty of similar background and experience, none of whom were recognized experts.

5. Faculty and Student Population - scale: 0 to 10 (see below)

Weight factor: 15/100

Criteria: This parameter is broken down into three sub-categories: a) Number of Faculty, b) Number of Students, and c) Student to Faculty Ratio. The scores given to the three following factors are to be added together once determined. This sum is the scale of 0 to 10 mentioned above.

a) Number of Faculty - scale: 0 to 3

Criteria: The intent of this factor is to measure the number of directly supporting faculty in the CEM program. Here a zero rating is given for no individuals devoted solely to the construction curriculum. Depending on circumstances the optimum may vary, but the author chose three to four as the desired

value if no other pertinent information was available. More than three to four curriculum specific faculty was viewed as possibly detrimental in that the program may not be tapping the capabilities from related departments or outside sources to cover some material. i.e. accounting, statistics, legal practices, etc.

b) Number of Students - scale: 0 to 3

Criteria: An academic program cannot survive and prosper without students enrolling in it and completing its requirements. Yet too great a number of students can over tax a program and render it less than optimal for all its participants. The author has found through discussion with CEM graduates that their perception of an optimum number of students in a year group lies between twenty-five and thirty. Therefore an optimum score of three was given to institutions with a yearly quota of twenty-five to thirty. Two points were allowed for enrollment of twenty to twenty-four as well as thirty-one to thirty-five and so forth to zero for less than fourteen or greater than forty.

c) Student to Faculty Ratio - scale: 0 to 4

Criteria: Obviously highly related to the two previous factors, the ratio gives an indication of the professor's accessability to the students. Too high a

ratio can mean a student is lost in the multitudes and may not receive meaningful counseling to plan his or her desired course of study. Too low can indicate a less than desireable program or possibly "phantom" faculty that are nearly impossible to reach. The ideal ratio on the author's system was between 8/1 and 10/1. Four points were awarded for ratio's in that interval. For schools having 11/1 or 7/1 three points were given and two for 12/1 or 6/1 ratios. A 5/1 or less and a 12/1 or greater obtained one point.

6. Entrance Requirements - scale: 0 to 10

Weight factor: 4/100

Criteria: Though fairly similar for most schools, there are a few key differences in entrance requirements. Undergraduate grade point average is for all intents and purposes a universal requirement, but the Graduate Record Examination is variable between institutions, some insist upon it while others may waive or not require it at all. The top rating was given to the institutions that stated up front the flexibility of their admissions policy. Favor was seen in the requirement of providing references from either supervisors or past professors to judge the capabilities of a prospective student rather than a one shot all day test. The desire for eliminating those persons most probably incapable of finishing a program and the need for a method of determining who is accepted and who is not is

acknowledged. For that reason this factor carries the least weight of all major categories.

7. Tuition Cost - scale: 0 to 10

Weight factor: 10/100

Criteria: When utilizing public funds, the concept of obtaining the best that money can buy is not often an acceptable criterion. Therefore getting the best education for the funds available becomes the bottom line. A cost comparison between the twenty-two schools surveyed was made and the least cost was selected for the optimum on the scale. A decrease of one point for each increase of $1,500 from the minimum was made. Tuition figures were calculated for out of state residents, due to the nature of the military, and were based on two semesters or three quarters for a full time student.

8. Institution Location - scale: 0 to 10

Weight factor: 7/100

Criteria: This parameter gives credit to those institutions located close to bases or posts that negate the need to move the military member lock, stock, and barrel for an assignment of usually twelve to eighteen months. Optimum score was given to institutions such as the University of California-Berkeley and Drexel which are both located in cities with significant military (in these cases Navy) presence. This allows an officer to either come from a tour in the area and then go to school or complete

the graduate program and then go to a job in the local area or possibly both without moving and costing any permanent change of station dollars(moving money). A minimal rating was given those universities (the majority of the ones investigated) in an area where no possible follow on tour could be realized and therefore no savings.

9. Officer Opinion - scale: 0 to 10

Weight factor: 15/100

Criteria: A set of questions requiring both subjective and objective evaluation of their program was asked of officers who had recently completed Construction Engineering and Management curricula at various universities. Individuals surveyed had graduated within the last four years and were serving on active duty at the time of the inquiry. The questions ranged from the rating the applicability of the course work and the flexibility of the program to would you be satisfied with your educational experience if you had been paying for the tuition yourself and not been on salary as you studied? A copy of the questionnaire is included in Appendix A.

The institution's score was developed by averaging the rating given on the eleven scaled questions and multiplying by two (The author found it easier to have individuals rate their answers on a scale of five. Individuals had less reservation with this and often would use a half point increment where they felt it was necessary). Note that an average of three or less

officers were queried from each school to develop the score. This was done because a number of schools had only one or two officer attendees over the past three years.

10. Program Versatility - scale: 1 to 20 (see below)

Weight factor: 30/100

Criteria: This parameter is subdivided into a set of five related categories with each being rated according to the criteria listed below. The scores of each category are then summed directly to become the score on the scale indicated above. The subdivisions evaluated are: a) Thesis Option, b) Base/Core Curriculum, c) Electives, d) Program Length, and e) Industry Consciousness.

a) Thesis Option - scale: 0 to 3

Criteria: A program that offers the individual student the option to prepare a thesis or take additional courses and complete a major research report or accomplish even more class work and have no major paper was considered the most flexible and advantageous and was awarded three points. Institutions having only the thesis and major report options were given a two. And schools with the thesis only criteria received one point on this sub-category scale.

b) Base/Core Curriculum - scale: 1 to 5

Criteria: Having not fully developed the desired baseline set of courses for each service, this sub-parameter is not utilized to its fullest capabilities here. In its final version, this rating system would compare the school required curriculum with that of the desired educational plan base for the officer. In this comparison it would determine what topics, if any, were not covered by the university's requirements but needed to satisfy the services' curriculum. The ability to complete both sets of requirements within the amount of units/credits needed for the degree would be worth two points. Having all course requirements of the school align with that of the service would be worth another two points. This would allow greater flexibility for the military member to follow his or her own interests while filling all the services' needs. One point was reserved for the institution with a total free form curriculum which allows the student free and unincumbered reign over the development of their education plan. Presumably the officer would produce an exemplary combination of coursework, all of which would be unquestionably related to his or her sub-specialty and follow on duties.

In this foreshortened version, the number of core curriculum credits or units was divided by the total number needed for degree completion. This ratio was

converted to a percentage and broken down into intervals of twenty points, then each interval was assigned a value. Five points was assigned to the interval of zero to twenty i.e. the program with the least amount of required coursework. A four was given to the set between twenty-one and forty, etc. with the scale bottoming out with only one point for a percentage between eighty-one and one hundred.

c) Electives - scale: 0 to 5 (see below)

Criteria: This sub-category is further divided down into three subdivisions, namely: i) Technical Courses, ii) Related Support Courses, iii) Transfer and Undergraduate Course Credit. The scores obtained in these subdivisions are summed to become the score on the scale listed above.

i) Technical Courses - scale: 0 to 2

Criteria: Maximum score was given to those programs that: 1. allowed unrestricted enrollment into the civil engineering "design and theory" courses available, 2. had a lack of or allowed the waiving of prerequisite requirements for technical courses, and 3. had available an extensive mix of study areas including, but not limited to, geotechnical, hazardous waste, structures, foundations, waste water, highway,

pavement design, etc.

ii) Related Support Courses - scale: 0 to 1.5

Criteria: Score in this subdivision was awarded in half point segments. The top score was assigned to the institution that: 1. had minimal restrictions on use of supporting coursework coupled with total number of credits allowed outside the major i.e. courses could be taken from any college within the university and a majority of total credits toward a degree could be these. 2. had a large number of departments, colleges, or schools within the university from which graduate courses could be selected. and 3. had a broad mix of related support topics offered by the other departments or colleges within the system.

iii) Transfer and Undergraduate Course Credit

Scale: 0 to 1.5

Criteria: Credit is given in this subdivision to the institutions that allow the use of transfer graduate credits along with some of their own undergraduate course credits toward the completion of their graduate program requirements. Being that the majority of institutions allow either or both of these methods, the magnitude of permitted use becomes the deciding factor in the scoring of the factor. Schools

with the maximum allowable transfer and undergraduate credits(as a percentage of total credits required) were given one and a half points. Those programs allowing neither of these forms of credit were rated with a zero.

d) Program Length - scale: 0 to 2

Criteria: Due to the cost of enrolling an officer in school and the lost productivity encountered while he or she is completing a program, it is advantageous to the government to minimize the time required to complete the masters degree requirements. It is recognized that the armed forces civil engineer groups employ individuals from a wide variety of scholastic backgrounds and not all can meet the graduate program requirements in a condensed time frame. Therefore though a nine month program is well thought of, the top score of two goes to those universities who can readily accommodate a variation in completion time. That is the programs with a normal twelve month duration that can be easily condensed or expanded by a quarter or summer semester if needed.

e) Industry Consciousness - scale: 0 to 5

Criteria: Believing that there is no substitute for experience, the author has given a good deal of credit

to the institutions that have sought out and utilized experts and captains of industry currently employed outside in the real world. Particular emphasis was given to the use of industry leaders such as officers or owners of major corporations and high ranking government officials. Major credit was awarded for entire courses taught by these individuals and lesser for a lecture series where the person was only heard from once on a limited basis.

How the Schools Measured Up

In employing this system the author obtained all information required by the parameters through either literature provided by the institution or conversations with respective school personnel. For the officer opinion factor, the nine scores obtained through interviews with officers who had recently attended the institutions were averaged and that figure listed for those institutions that had no recent officer attendance. Having compiled all the information and utilized the scoring criteria listed, a numerical score for each parameter was developed (see Figure 1 - Appendix B). The score awarded on each parameter scale is then multiplied by its weight factor, except for the Program category which is divided by two first. Once all weight factors have been employed, the resultant products are summed to find the school's rating out of a possible ten point maximum (see Figure 2 - Appendix B).

Note that this system is not designed to make overall qualitative and quantitative judgement of institutions and programs. It is not an attempt to find the only worthwhile program nor does it suggest or mean to suggest those institutions and programs at the end of the listing are in any way inferior to those at the top. It merely measures the parameters developed by the author, in this case, for the military's needs, and ranks the schools accordingly.

SUMMARY AND CONCLUSIONS

Construction Engineering and Management is now a well-established, expanding, and maturing profession. It requires a broad set of educational possibilities to cover its extensive range of applications. Other than a set of generally accepted major categories of study, there is no specific core of course work required to complete a masters degree program in Construction Engineering and Management (other than institution specific). Various universities across the country offer a myriad of programs in CE&M programs, each with a slightly or widely differing approach to or idea of what a proper curriculum should be. There is no alignment between, nor does the writer advocate an alignment between the institutions programs. This would be counterproductive to the effort to develop and promote all the domain encompassed by CE&M.

The U.S. military is a major consumer of these programs, sending upwards of fifty officers to school each year to complete the masters degree curriculum. Even though the services are utilizing these programs extensively, there has been no documented attempt to assure that a common education base is obtained by each military member. The author strongly advocates that each service research its educational requirements and prepare a set of base courses or topics to be covered in each officers educational program at graduate school. Another

desireable tool to assure that officers are receiving the best education for the dollars available is a rating system such as was developed in this paper. Such a system is capable of unbiasedly evaluating any and all factors the developer deems relevant. The author realizes that his set of parameters and criteria are not the final chapter in program evaluation for the military or anyone else. But it is a starting place from which further assessment of needs, goals, desires, and objectives can be made. It is not the intention of this system, nor the point of this paper, to select one institution and proclaim it the panacea of Construction Engineering and Management programs for the military civil engineer. Its true desire is to enlighten readers to the fact that a wide variety of programs exist, all respectable, but not necessarily all geared to the same specific final product.

A second purpose of this writing is to cajole the military members into further assessing their objectives and desires in attending graduate school. If and when these two events occur, the government will begin to receive the optimal return on its educational dollar.

As I complete this undertaking, I find there are several more avenues of this topic where additional research and study can be performed. As stated earlier, an overall analysis by each service should be conducted to establish a set of base subjects

necessary to prepare the officer for future assignments. Once the desired set of base topics is determined, it must be compared to the present curriculum at each institution offering a CE&M program. In conjunction with this comparison, a course by course review could be performed on each school's curriculum to further evaluate the program's flexibility and desirability in relation to the individual's or organization's needs.

A survey of senior Army and Air Force civil engineering officers can be made to verify if they have similar attitudes toward the programs as exhibited by the Navy officers. The assessment of applicability can then be made on a service by service basis to more accurately reflect each units requirements and desires.

Further research into the possibility of the services providing their own program at one of their institutions for higher education should be accomplished. Given the volume of officers sent through programs of this type, it may prove cost effective to develop a curriculum to suit all the needs and hire a faculty to teach those courses.

A cost analysis of sending an officer back to his or her home of record (where applicable) to acquire an advanced education at resident in-state tuition rates can be developed. Tied to this could be a cost analysis of having the officer

attend an acceptable institution local to his or her duty station in order to conserve PCS funds (moving money).

Another possible method of analysis that could be performed on the data collected would be to provide two separate rating systems. One system might cover the objective and measurable parameters developed and the second could rate those categories calling for subjective and therefore opinionated responses. Such a combination would provide a better view of the programs being evaluated.

As can be concluded from the material presented, the graduate school experience, and particularly the Construction Engineering and Management curriculum is applicable and beneficial to both the individual officer and to the U.S Armed Forces civil engineer groups as a whole. However, the previously mentioned revisions and additions to the military's post graduate school program could make a good program even better and turn out officers best able to accomplish the mission of the military civil engineers.

APPENDIX - A

NAME: _____

SCHOOL: _____

PROGRAM: _____

YEAR GRAD: _____

SENIOR OFFICER'S

QUESTIONNAIRE

1. What is your view as construction management as a masters degree program and how relevant is it to the work you've done?

2. How technically oriented does the program need to be to best serve the officer's needs?

3. Are there any courses you would suggest to a student in school today?

4. What length of time were you at graduate school and what do you feel is an appropriate time frame?

5. Did your program require a thesis and do you believe that that is the best use of an officer's time in school?

6. Besides qualifying individuals for more responsible billets, what other enhancements do you feel the overall graduate school program offers?

7. Any other comments?

FIGURE 1.

NAME:_____ GRADUATE MASTERS DEGREE

SCHOOL:_____ QUESTIONNAIRE

YEAR GRAD:_____ page 1 of 2

1. Was the program pertinent to work you've done or expect to do?

scale 1 2 3 4 5

2. What's your opinion of the mix of the course work?

scale 1 2 3 4 5

3. What's your opinion of the program's flexibility?

scale 1 2 3 4 5

4. Was the curriculum challenging to you?

scale 1 2 3 4 5

5. Would you choose the university again knowing what you do now?

scale 1 2 3 4 5

6. Would you recommend it to fellow officers?

scale 1 2 3 4 5

7. Would you be satisfied if you were paying for this education?

scale 1 2 3 4 5

8. Were you impressed with the professionalism of instruction?

scale 1 2 3 4 5

9. Do you feel you received quality advising?

scale 1 2 3 4 5

10. Were the graduate students treated appropriately?

scale 1 2 3 4 5

11. Was the program of appropriate length?

scale 1 2 3 4 5

ON ALL THE ABOVE QUESTIONS (5) IS OPTIMUM AND (1) IS MINIMUM

GRADUATE MASTERS DEGREE

QUESTIONNAIRE

1. What was the most positive thing about your grad school tour?

2. Were there any negatives about the experience?

3. What was the biggest plus about your advanced education?

4. How did this compare with your undergraduate experience?

5. Any additional comments?

FIGURE 2.

APPENDIX - B

PARAMETER DATA BASE

PARAMETER \ SCHOOL	UNIV COLO	BRIL	PENN STATE	U NEW MEX	UNIV ILL	N C STATE	TEXAS A&M	PURDUE	UNIV PITT	UNIV MICH	GA TECH	WPSTR POLYT	U CAL BERK	UNIV WASH	SAN JOSE	TEXAS	RUT-GERS	UNIV FLA	MIT	STANF
SCHOOL PRESTIGE	6	1	5	1	10	3	4	9	1	9	4	1	10	8	1	6	3	3	10	10
WELL KNOWN FACULTY	5	1	7	5	8	6	6	9	5	7	6	3	9	8	3	8	6	7	10	10
DIVERSITY OF FACULTY	7	2	8	5	8	7	5	7	6	7	7	5	8	7	4	8	6	7	10	10
STUDENT-FACULTY R'S	9	5	9	4	8	7	7	6	7	5	6	4	8	9	5	8	6	7	9	9
a) # of Faculty	3	3	3	2	3	2	2	1	2	3	2	2	2	3	2	3	2	3	3	3
b) # of Students	3	1	3	1	2	2	2	3	2	1	3	1	3	3	1	2	2	2	3	3
c) S/F Ratio	3	1	3	1	3	3	3	2	3	1	1	1	3	3	2	3	2	2	3	3
ENTRANCE REQUIREMENT	8	10	6	6	5	9	5	8	9	7	9	9	6	5	8	6	7	6	2	2
COST $$$$$$	6	7	4	9	5	9	10	7	6	0	9	7	10	6	9	9	6	5	1	0
LOCATION	2	9	2	2	2	4	2	2	2	2	2	2	10	8	7	2	7	5	5	10
OFFICER OPINION	7.5	7.5	7.6	7.5	6.7	7.5	7.5	7.5	7.5	7.5	4.8	7.5	8.5	4.7	7.5	7.8	7.5	8.1	9.9	9.7
PROGRAM	12.5	5	11	5	13	11	10.5	12.5	11	12.5	12.5	11.5	15.5	11.5	8	12	9.5	12.5	17	17
a) Thesis Option	3	1	1	1	2	1	1	2	2	1	2	2	2	2	1	2	2	2	1	3
b) Core Curriculum	3	1	3	1	3	3	2	2	3	4	3	4	4	3	3	4	3	3	5	4
c) Electives	3.5	1	4	1	3	3	3.5	3.5	3	3.5	3.5	2.5	3.5	3.5	2	3	2.5	3.5	4	3
i) technical	2	0	2	0	1	1	2	2	2	2	2	1	2	2	1	2	1	2	2	1
ii) related	1	0.5	1.5	0.5	1	1	1	1	0.5	1	1	1	1	1	0.5	0.5	0.5	0.5	1.5	1
iii) trnsfr/undgr	0.5	0.5	0.5	0.5	1	1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	1	0.5	1
d) Program Length	2	1	1	1	2	2	2	2	2	2	2	2	2	1	1	1	1	2	2	2
e) Industry Consci	1	1	2	1	3	2	2	3	1	2	2	1	4	2	1	2	2	2	5	5

FIGURE 1. Listing of all Parameter Scores for Schools Evaluated

RANK	INSTITUTION	RATING
1	University of California, Berkeley	8.43
2	Stanford University	8.04
3	Massachusetts Institute of Technology	7.82
4	University of Texas, Austin	6.97
5	University of Illinois	6.64
6	Purdue University	6.61
7	University of Washington	6.58
8	University of Colorado	6.56
9	North Carolina State University	6.41
10	University of Florida	6.32
11	Pennsylvania State University	6.21
12	Texas A&M University	6.03
13	Georgia Institute of Technology	6.00
14	Rutgers University	5.78
15	University of Pittsburgh	5.72
16	University of Michigan	5.62
17	San Jose State University	5.32
18	Worcester Polytechnic Institute	5.26
19	Drexel University	4.63
20	University of New Mexico	4.47

FIGURE 2. Listing of Schools by Rank

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The following institutions provided curriculum literature for this research project:

San Jose State University

Stanford University

University of California, Berkeley

University of Colorado

University of Florida

Georgia Institute of Technology

University of Illinois

Purdue University

Massachusetts Institute of Technology

Worcester Polytechnic Institute

University of Michigan

Rutgers University

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